## REMARKS

The rejection has been considered at length. However, for the reasons set forth below, it is believed that the claimed subject matter would not have been rendered obvious by the cited references.

Claims 1, 3-5 and 8-33 are pending, and claims 1, 3-5, 8-10, 12 and 17-22 have been examined on the merits. Claims 18 and 19 have been amended hereinabove and claims 34-35 have been added. Support for new claims 34-35 can be found in the specification at page 14, lines 20-22. No new matter has been added.

In the Office Action, the Examiner objected to the specification and to claims 18-19 because of informalities. The specification and claims 18-19 have been amended hereinabove to correct such informalities, rendering the objections moot.

Further, claims 1, 3-5, 8-10, 12 and 17-22 have been rejected under 35 U.S.C. § 103(a) as being obvious over Yamada (U.S. Patent No. 5,024,927, hereinafter "Yamada") in view of Saito et al (U.S. Patent No. 5,021,114, hereinafter "Saito"). Applicants respectfully traverse.

As set forth in the previous responses, Applicants' claimed invention is directed to a method for applying a hybrid coating comprised of an inorganic and organic component. The inorganic component is generated in high electron density high-frequency plasma, wherein the high electron density high-frequency plasma is pulsed at a pulsed frequency of between 1 Hz to 100 Hz and wherein when the pulse is of 25 Hz, the duty cycle is between 5% to 10% (*e.g.*, page 2, lines 20-27, page 10, lines 20-23, page 12, lines 26-29 and page 14, lines 20-22).

Yamada does not teach Applicants' claimed invention. Yamada only provides for alternate current (AC) which either is deemed to be the normal source of current, wherein the duty cycle is 50%, or it is deemed to be indicating so-called "radio frequency glow discharge",

wherein a sine-wave current of radio-frequency is applied, also indicating a duty cycle of 50% (*e.g.*, col. 7, lines 21-26). Further, Yamada discloses that the RF frequency is 100 KHz to 50 MHz (*e.g.*, col. 7, lines 31-32).

Saito is completely silent with regards to pulsed plasma. Accordingly, for the following reasons the combination of Yamada with Saito does not teach, disclose or even suggested the claimed limitations.

As an initial matter the presently claimed invention is directed to a pulsed plasma as described in the document attached hereto (Wikipedia, http/en.wikipedia.org/wiki/Electric_glow_discharge):

> "Both radio-frequency and direct-current glow discharges can be operated in pulsed mode, where the potential is turned on and off. This allows higher instantaneous powers to be applied without excessively heating the cathode. These higher instantaneous powers produce higher instantaneous signals, aiding detection. Combining time-resolved detection with pulsed powering results in additional benefits. In atomic emission, analyte atoms emit during different portions of the pulse than background atoms, allowing the two to be discriminated. Analogously, in mass spectrometry, sample and background ions are created at different times."

Thus, in contrast to the Examiner's statement on page 4 of the Office Action, the teaching of Yamada is not the claimed pulsed plasma. Further, unlike in Yamada, the presently claimed invention comprises a pulsed frequency of between 1 Hz to 100 Hz which is 1000 times less than the lower value of 100 kHz disclosed by Yamada. Accordingly, it is respectfully submitted that

the combination of the cited references does not disclose all of the claimed limitations and would not have rendered obvious the claimed subject matter. Accordingly, withdrawal of the rejections of the claims under 35 U.S.C. § 103(a) is respectfully requested.

This response is being filed within the shortened statutory period for response, thus, no fees are believed to be due. If, on the other hand, it is determined that further fees are necessary or any overpayment has been made, the Commissioner is hereby authorized to debit or credit such sum to Deposit Account No. 02-2275.

Pursuant to 37 C.F.R. § 1.136(a), please treat this and any concurrent or future reply in this application that requires a petition for an extension of time of its timely submission as incorporating a petition for extension of time for the appropriate length of time. The fee associated herewith is to be charged to the above-mentioned deposit account.

An early and favorable action on the merits is earnestly solicited.

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Respectfully submitted,

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Enclosure

# Electric glow discharge

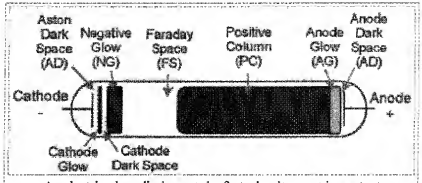
From Wikipedia, the free encyclopedia

**Electric glow discharge** is a type of plasma formed by passing a current at 100 V to several kV through a gas at low pressure, usually argon or another noble gas. It is found in products such as fluorescent lights and plasma-screen televisions, and is used in plasma physics and analytical chemistry.

## Contents



## Basic operating mechanism




An electric glow discharge tube featuring its most important characteristics: (a) An anode and cathode at each end (b) Aston dark space (c) Cathode glow (d) Cathode dark space (also called Crookes dark space, or Hittorf dark space) (e) Negative glow (f) Faraday space (g) Positive column (h) Anode glow (i) Anode dark space.

The simplest type of glow discharge is a direct-current glow discharge. In its simplest form, it consists of two electrodes in a cell held at low pressure (0.1–10 torr; about $1/10000^{th}$ to $1/100^{th}$ of atmospheric pressure). The cell is typically filled with argon, but other gases can also be used. An electric potential of several hundred volts is applied between the two electrodes. A small fraction of the population of atoms within the cell is initially ionized through random processes (thermal collisions between atoms or with alpha particles, for example). The ions (which are positively charged) are driven towards the cathode by the electric potential, and the electrons are driven towards the anode by the same potential. The initial population of ions and electrons collides with other atoms, ionizing them. As long as the potential is maintained, a population of ions and electrons remains.

Some of the ions' kinetic energy is transferred to the cathode. This happens partially through the ions striking the cathode directly. The primary mechanism, however, is less direct. Ions strike the more numerous neutral gas atoms, transferring a portion of their energy to them. These neutral atoms then strike the cathode. Whichever species (ions or atoms) strike the cathode, collisions within the cathode redistribute this energy until a portion of the cathode is ejected, typically in the form of free atoms. This process is

known as sputtering. Once free of the cathode, atoms move into the bulk of the glow discharge through drift and due to the energy they gained from sputtering. The atoms can then be collisionally excited. These collisions may be with ions, electrons, or other atoms that have been previously excited by collisions with ions, electrons, or atoms. Once excited, atoms will lose their energy fairly quickly. Of the various ways that this energy can be lost, the most important is radiatively, meaning that a photon is released to carry the energy away. In optical atomic spectroscopy, the wavelength of this photon can be used to determine the identity of the atom (that is, which chemical element it is) and the number of photons is directly proportional to the concentration of that element in the sample. Some collisions (those of high enough energy) will cause ionization. In atomic mass spectrometry, these ions are detected. Their mass identifies the type of atoms and their quantity reveals the amount of that element in the sample.

The figure above shows the main regions that may be present in a glow discharge. Regions described as "glows" emit significant light; regions labeled as "dark spaces" do not. As the discharge becomes more extended (i.e., stretched horizontally in the geometry of the figure), the positive column may become striated. That is, alternating dark and bright regions may form. Relatedly, compressing the discharge horizontally will result in fewer regions. The positive column will be compressed while the negative glow will remain the same size, and, with small enough gaps, the positive column will disappear altogether. In an analytical glow discharge, the discharge is primarily a negative glow with dark region above and below it.

Below the ionization voltage or breakdown voltage there is no glow, but as the voltage increases to the ionization point the Townsend discharge happens just as Glow Discharge becomes visible, this is the start of the normal glow range. As the voltage is increased above the Normal Glow range, Abnormal Glow begins. If the Voltage is increased to the point the cathode glow covers the entire cathode Arc Discharge begins.[1]

## Use in analytical chemistry

Glow discharges can be used to analyze the elemental, and sometimes molecular, composition of solids, liquids, and gases, but elemental analysis of solids is by far the most common. In this arrangement, the sample is used as the cathode. As mentioned earlier, gas ions and atoms striking the sample surface knock atoms off of it (a process known as sputtering). The sputtered atoms, now in the gas phase, can be detected by atomic absorption, but this is a comparatively rare strategy. Instead, atomic emission and mass spectrometry are usually used. Collisions between the gas-phase sample atoms and the plasma gas pass energy to the sample atoms. This energy can excite the atoms, after which they can lose their energy through atomic emission. By observing the wavelength of the emitted light, the atom's identity can be determined. By observing the intensity of the emission, the concentration of atoms of that type can be determined. Energy gained through collisions can also ionize the sample atoms. The ions can then be detected by mass spectrometry. In this case, it is the mass of the ions that identified the element and the number of ions that reflects the concentration

Both bulk and depth analysis of solids may be performed with glow discharge. Bulk analysis assumes that the sample is fairly homogeneous and averages the emission or mass spectrometric signal over time. Depth analysis relies on the fact that the depth increases as time goes by. Tracking the signal in time, therefore, is the same as tracking the elemental composition in depth. Depth analysis requires greater control over operational parameters. For example, conditions (current, potential, pressure) need to be adjusted so that the crater produced by sputtering is flat bottom (that is, so that the depth analyzed over the crater area is uniform). In bulk measurement, a rough or rounded crater bottom would not adversely impact analysis. Under the best conditions, depth resolution in the single nanometer range has been achieved (in fact, within-molecule resolution has been demonstrated).

The chemistry of ions and neutrals in vacuum is called gas phase ion chemistry and is part of the analytical study that includes Electric glow discharge.

## Powering modes

In analytical chemistry, glow discharges are most often operated in direct-current mode. For this mode, the cathode (which is the sample in solids analysis) must be conductive. The potential, pressure, and current are interrelated. Only two can be directly controlled at once, while the third must be allowed to vary. The pressure is most typically held constant, but other schemes may be used. The pressure and current may be held constant, while potential is allowed to vary. The pressure and voltage may be held constant while the current is allowed to vary. The power (product of voltage and current) may be held constant while the pressure is allowed to vary.

Glow discharges may also be operated in radio-frequency mode. In this mode, a sine wave current of radio-frequency is applied to the cathode. Because alternating currents can pass through non-conductive materials, this allows sampling of such materials, greatly expanding the applicability of the technique.

Both radio-frequency and direct-current glow discharges can be operated in pulsed mode, where the potential is turned on and off. This allows higher instantaneous powers to be applied without excessively heating the cathode. These higher instantaneous powers produce higher instantaneous signals, aiding detection. Combining time-resolved detection with pulsed powering results in additional benefits. In atomic emission, analyte atoms emit during different portions of the pulse than background atoms, allowing the two to be discriminated. Analogously, in mass spectrometry, sample and background ions are created at different times.

## Types

There are various types of glow discharge examples include: highpressure glow discharge, hollow cathode discharge, spray discharge.

## See also

- Electric arc discharge
- X-ray tube
- Fluorescent lamp, neon lamp, and plasma lamp
- An example of gas discharge at various low pressures (http://www.flickr.com/photos/milan_karakas/4065985871/sizes/o/)

## References

1. ^ Principles of Electronics By V.K. Mehta ISBN 8121924502

- S. Flügge (edited by) (1956). *Handbuch der Physik/Encyclopedia of Physics band/volume XXI - Electron-emission • Gas discharges I.* Springer-Verlag. First chapter of the article *Secondary effects* by P.F. Little.
- R. Kenneth Marcus (Ed.) (1993). *Glow Discharge Spectroscopies.* Kluwer Academic Publishers (Modern Analytical Chemistry). ISBN 0306443961.

Categories: Plasma physics | Gas discharge lamps | Lighting | Electrical breakdown | Ion source | Analytical chemistry